METHOD AND APPARATUS FOR TRANSMITTING A REFERENCE SIGNAL IN A MULTI-ANTENNA SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation of co-pending U.S. patent application Ser. No. 14/968,304 filed on Dec. 14, 2015, which is a Continuation of U.S. patent application Ser. No. 14/524,833 filed on Oct. 27, 2014 (now U.S. Pat. No. 9,236,988 issued on Jan. 12, 2016), which is a Continuation of U.S. patent application Ser. No. 13/496,365 filed on Jun. 20, 2012 (now U.S. Pat. No. 8,902,849 issued on Dec. 2, 2014), which is the National Phase of PCT/KR2010/006360 filed on Sep. 16, 2010, which claims priority under 35 U.S.C. 119(e) to U.S. Provisional Application Nos. 61/242,810 and 61/293,203 filed on Sep. 16, 2009 and Jan. 8, 2010 respectively, and under 35 U.S.C. 119(a) to Patent Application No. 10-2010-0091228 filed in the Republic of Korea on Sep. 16, 2010, all of which are hereby expressly incorporated by reference into the present application.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to wireless communications, and more particularly, to a method and apparatus for transmitting a reference signal in a multi-antenna system.

[0003] Effective transmission/reception methods and utilizations have been proposed for a broadband wireless communication system to maximize efficiency of radio resources. An orthogonal frequency division multiplexing (OFDM) system capable of reducing inter-symbol interference (ISI) with a low complexity is taken into consideration as one of next generation wireless communication systems. In the OFDM, a serially input data symbol is converted into N parallel data symbols, and is then transmitted by being carried on each of separated N subcarriers. The subcarriers maintain orthogonality in a frequency dimension. Each orthogonal channel experiences mutually independent frequency selective fading, and an interval of a transmitted symbol is increased, thereby minimizing inter-symbol interference.

[0004] When a system uses the OFDM as a modulation scheme, orthogonal frequency division multiple access (OFDMA) is a multiple access scheme in which multiple access is achieved by independently providing some of available subcarriers to a plurality of users. In the OFDMA, frequency resources (i.e., subcarriers) are provided to the respective users, and the respective frequency resources do not overlap with one another in general since they are independently provided to the plurality of users. Consequently, the frequency resources are allocated to the respective users in a mutually exclusive manner. In an OFDMA system, frequency diversity for multiple users can be obtained by using frequency selective scheduling, and subcarriers can be allocated variously according to a permutation rule for the subcarriers. In addition, a spatial multiplexing scheme using multiple antennas can be used to increase efficiency of a spatial domain.

[0005] MIMO technology can be used to improve the efficiency of data transmission and reception using multiple transmission antennas and multiple reception antennas. MIMO technology may include a space frequency block code (SFBC), a space time block code (STBC), a cyclic delay diversity (CDD), a frequency switched transmit diversity (FSTD), a time switched transmit diversity (TSTD), a precoding vector switching (PVS), spatial multiplexing (SM) for implementing diversity. An MIMO channel matrix according to the number of reception antennas and the number of transmission antennas can be decomposed into a number of independent channels. Each of the independent channels is called a layer or stream. The number of layers is called a rank.

[0006] In wireless communication systems, it is necessary to estimate an uplink channel or a downlink channel for the purpose of the transmission and reception of data, the acquisition of system synchronization, and the feedback of channel information. In wireless communication system environments, fading is generated because of multi-path time latency. A process of restoring a transmit signal by compensating for the distortion of the signal resulting from a sudden change in the environment due to such fading is referred to as channel estimation. It is also necessary to measure the state of a channel for a cell to which a user equipment belongs or other cells. To estimate a channel or measure the state of a channel, a reference signal (RS) which is known to both a transmitter and a receiver can be used.

[0007] A subcarrier used to transmit the reference signal is referred to as a reference signal subcarrier, and a subcarrier used to transmit data is referred to as a data subcarrier. In an OFDM system, a method of assigning the reference signal includes a method of assigning the reference signal to all the subcarriers and a method of assigning the reference signal between data subcarriers. The method of assigning the reference signal to all the subcarriers is performed using a signal including only the reference signal, such as a preamble signal, in order to obtain the throughput of channel estimation. If this method is used, the performance of channel estimation can be improved as compared with the method of assigning the reference signal between data subcarriers because the density of reference signals is in general high. However, since the amount of transmitted data is small in the method of assigning the reference signal to all the subcarriers, the method of assigning the reference signal between data subcarriers is used in order to increase the amount of transmitted data. If the method of assigning the reference signal between data subcarriers is used, the performance of channel estimation can be deteriorated because the density of reference signals is low. Accordingly, the reference signals should be properly arranged in order to minimize such deterioration.

[0008] A receiver can estimate a channel by separating information about a reference signal from a received signal because it knows the information about a reference signal and can accurately estimate data, transmitted by a transmit stage, by compensating for an estimated channel value. Assuming that the reference signal transmitted by the transmitter is p, channel information experienced by the reference signal during transmission is h, thermal noise occurring in the receiver is n, and the signal received by the receiver is y, it can result in $y=h \cdot p+n$. Here, since the receiver already knows the reference signal p, it can estimate a channel information value $\hat{h}$ using Equation 1 in the case in which a least square (LS) method is used.

[0009] [Equation 1]

$$\hat{h}=y/p=h+n/p=h+\hat{h}$$